

# Airborne Snow Observatories

*Foundational data for resilient water management*

Jeff Deems | Airborne Snow Observatories, Inc.



Elk Range  
ASO Snow Depth  
April 2019



# Basin snowpack indexed using station data

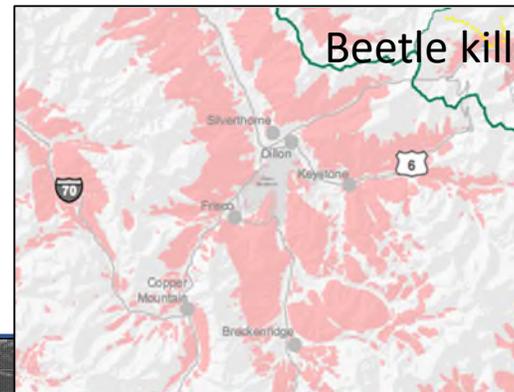


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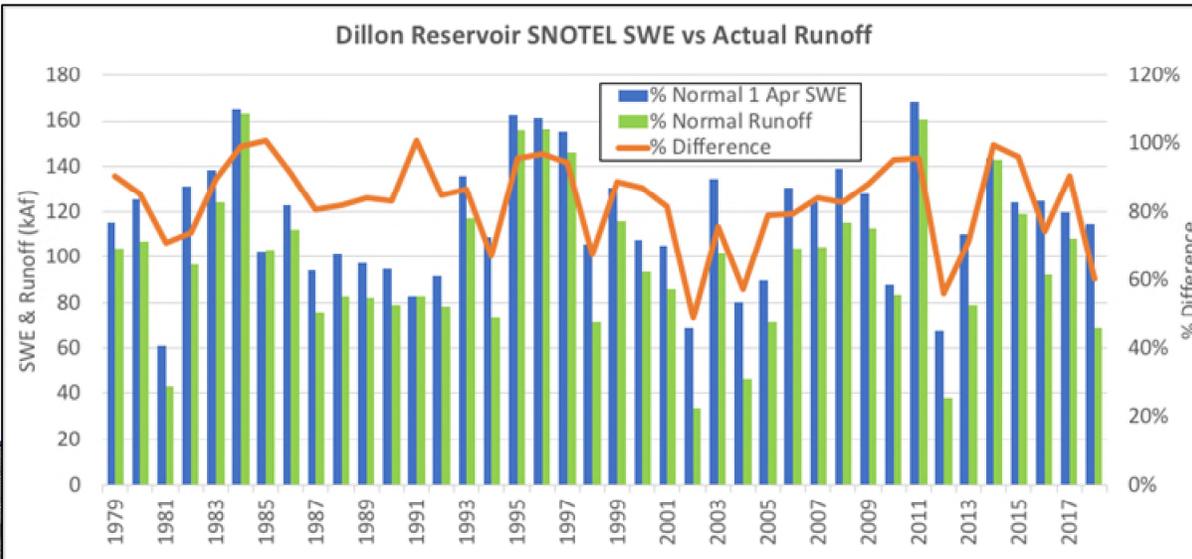


# History is an increasingly poor guide to the present

- forecasts based on historic data assume that calibrations apply to current conditions
- forecast uncertainty demands a wide margin
- accurate & complete SWE mapping is a foundation for reduced forecast uncertainty



	April Forecast	Obs Inflow	% Difference
1999	120	197	-39%
2000	155	159	-2%
2001	150	146	3%
2002	59	57	4%
2003	170	173	-2%
2004	100	78	28%
2005	125	120	4%
2006	210	176	19%
2007	150	177	-15%
2008	200	195	2%
2009	180	192	-6%
2010	120	142	-15%
2011	225	272	-17%
2012	100	64	56%
2013	100	134	-25%
2014	250	242	3%
2015	166	202	-18%
2016	167	157	7%
2017	195	184	6%
2018	137	117	17%



Airborne Snow

Forecast > 10% Low

Forecast > 10% High

# Airborne Snow Observatories, Inc.

*mapping the two most critical snow properties to forecast runoff volume & timing*

## Snow Water Equivalent

Snow depth from lidar elevation

SWE from coupling with obs & modeled density

## Snow Albedo

HySpex VSWIR spectrometers

Albedo & surface properties

## Physical Modeling

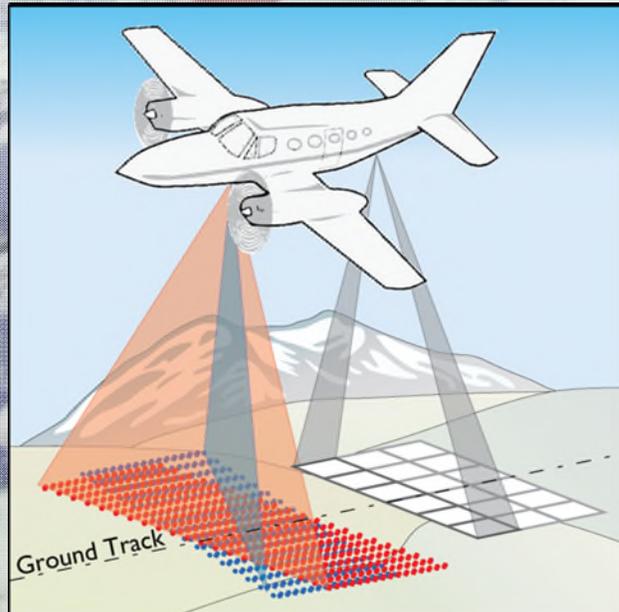
Coupled lidar & spectrometer

Physical snowpack & runoff modeling

## Operations

Unique high-altitude operations

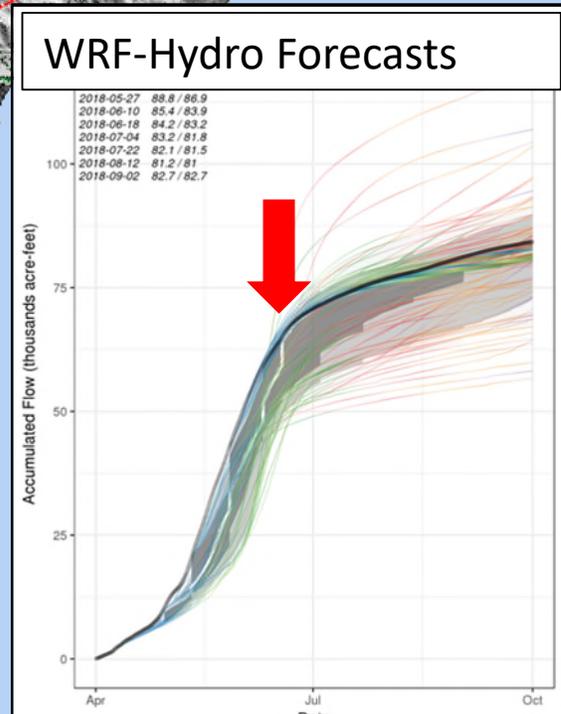
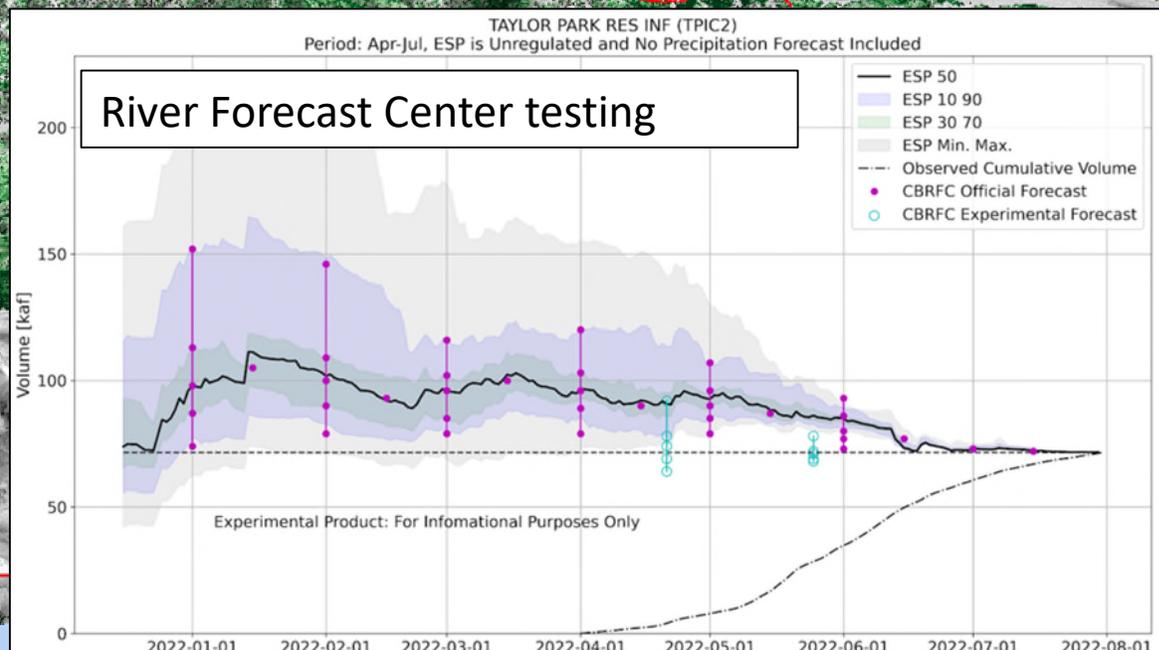
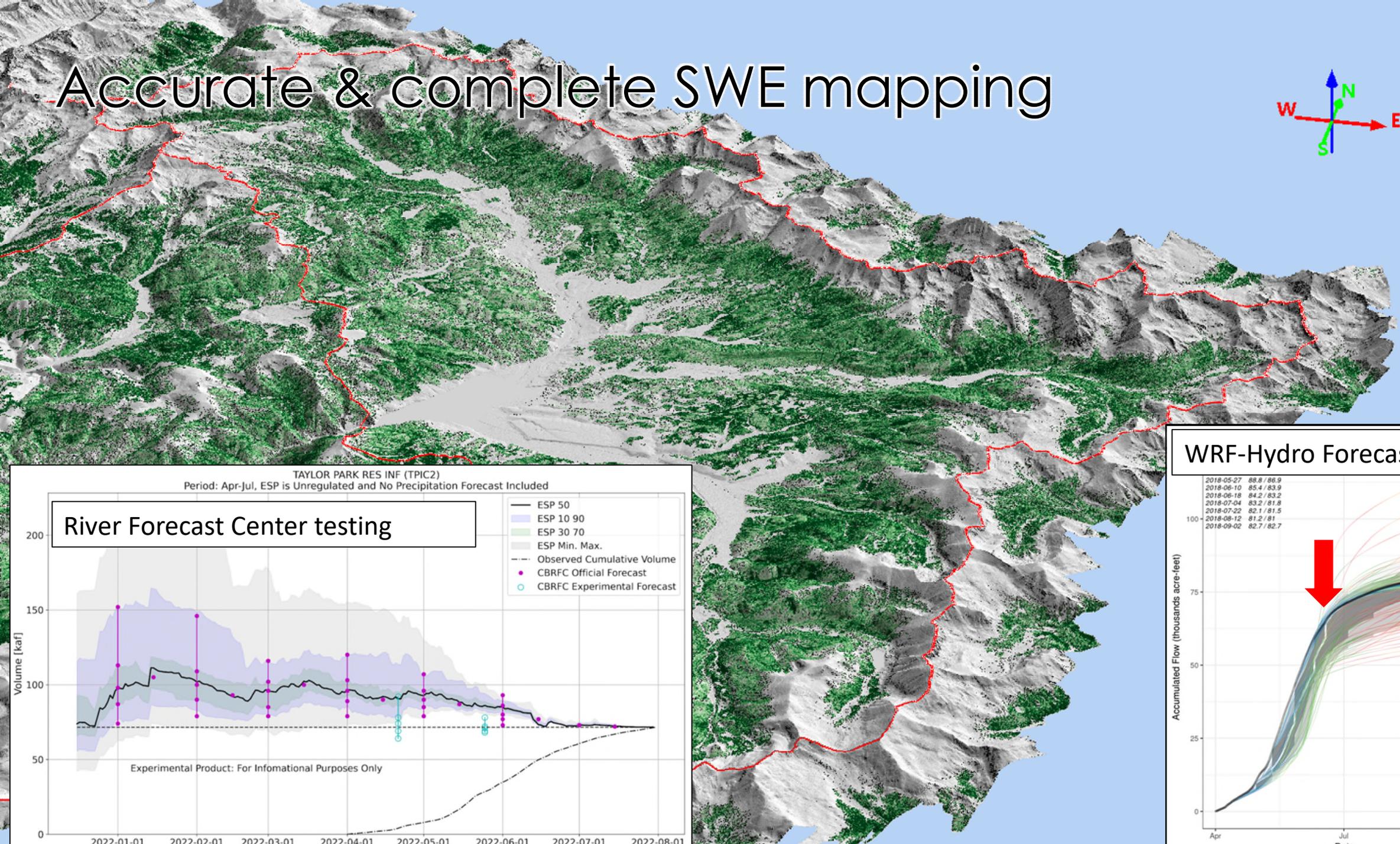
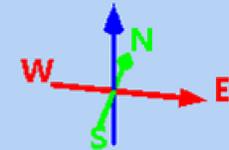
Unique rapid product turnaround



JPL

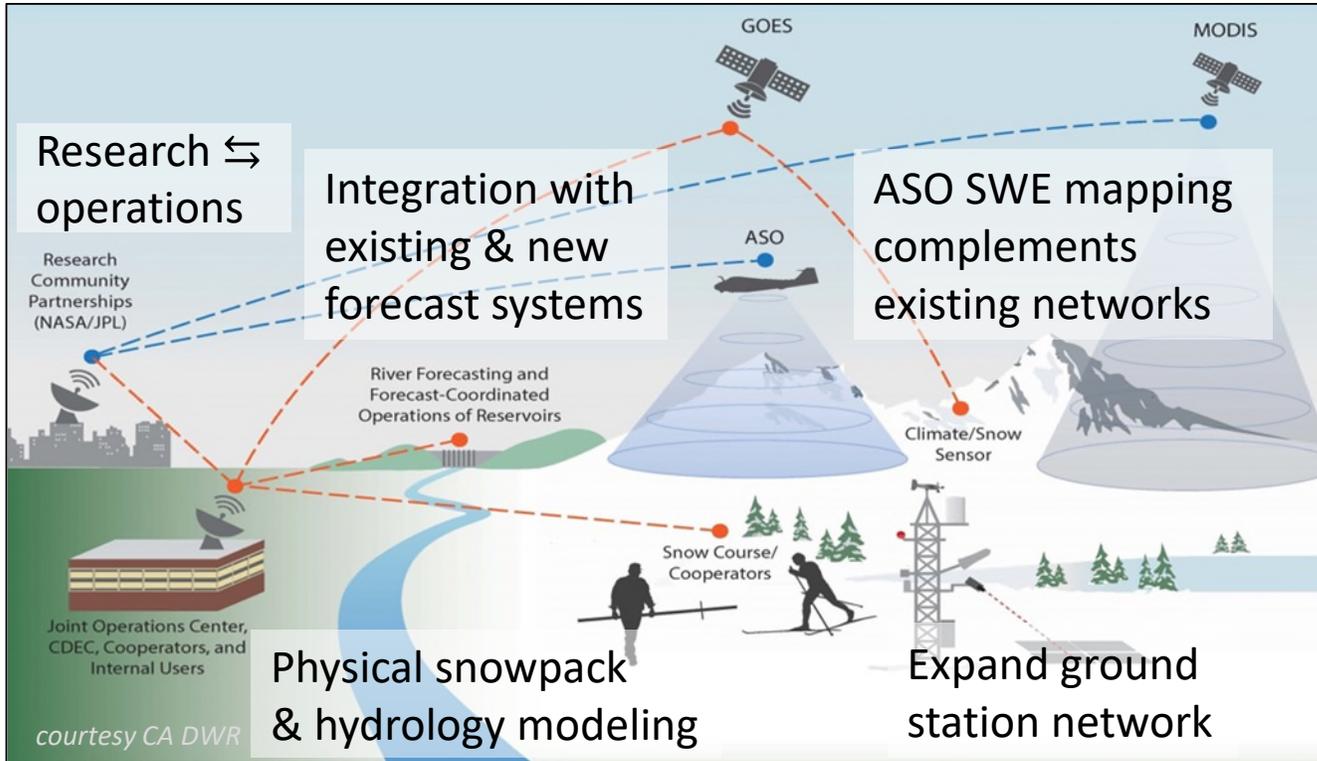


# Accurate & complete SWE mapping



# Next Generation Water Management in Colorado

## *An integrated monitoring & forecasting system*



## **Evolving challenges & programs**

- **adaptation** to changing hydroclimate & watershed conditions
- providing accurate & complete snowpack data to experienced forecast teams
- realizing full potential of advanced forecast model systems

## **ASO is the cornerstone of this vision**

- the **only, highly-accurate, full-coverage measurement of snow depth, SWE, & albedo**
- forecast improvement & decision support

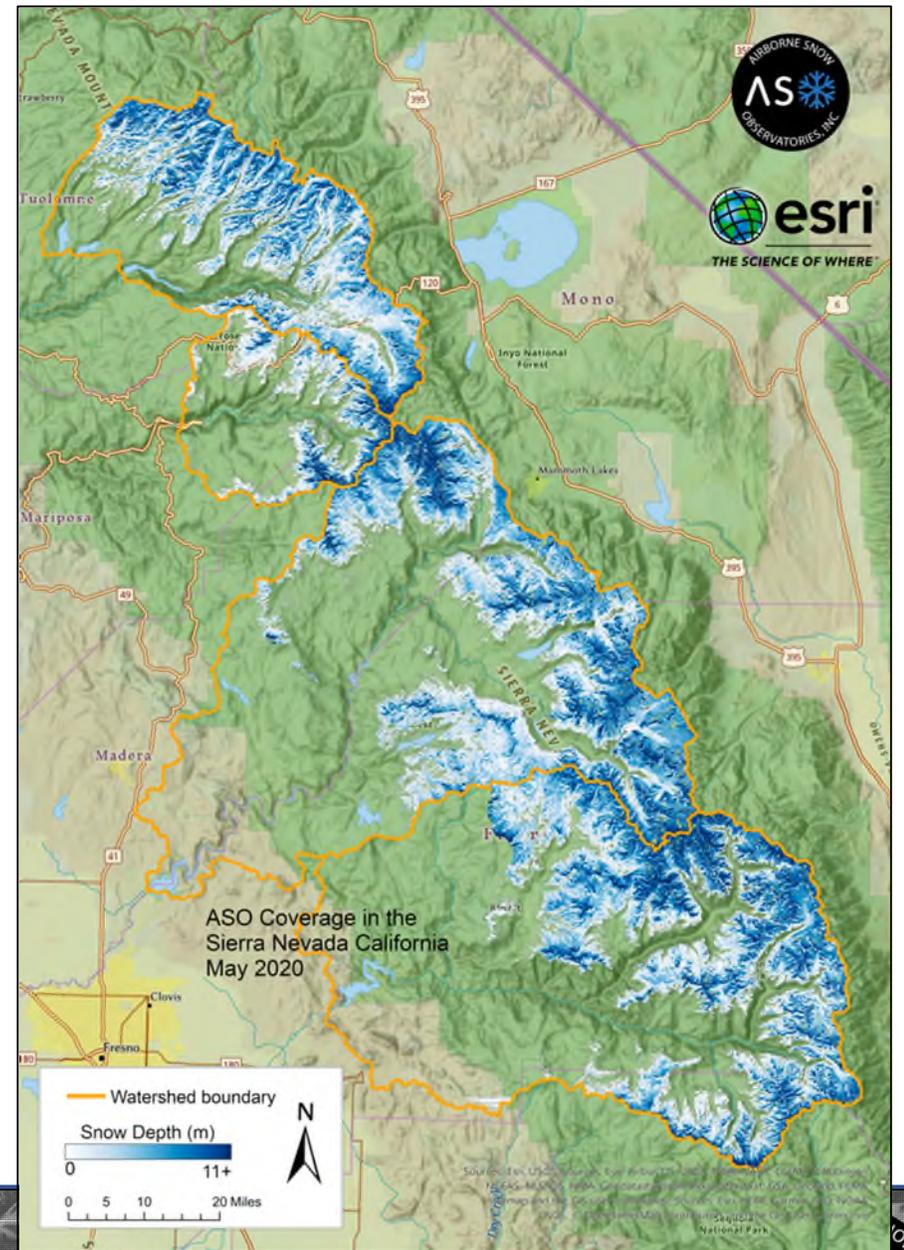
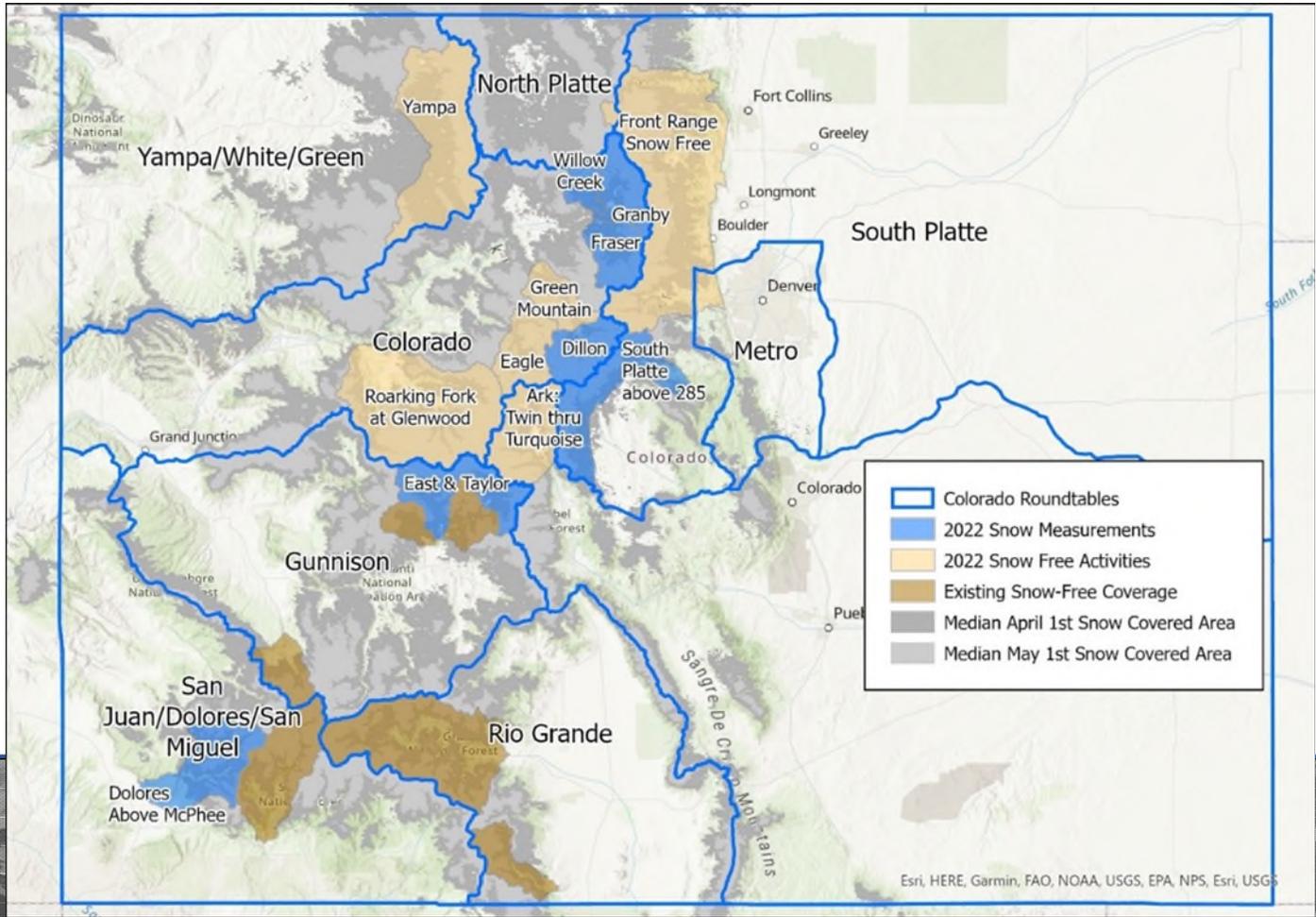
California Cooperative Snow Survey members estimate value of ASO forecast improvements

> \$600M annual for water supply only or (40:1 ROI)

> \$1.25B annual for supply, hydro, recharge, ecosystem, operational flexibility (80:1 ROI)

# Pathway to a sustained program

- stakeholder-funded efforts to-date demonstrate urgency
- CASM stakeholder group working to implement build-out





# Colorado Airborne Snow Measurement Program Update

Taylor Winchell, Denver Water

August 24<sup>th</sup>, 2022

## Overview

- CASM Background
- California's ASO Program
- CASM vision
- Water Plan Grant
- Next Steps for CASM

# Colorado Airborne Snow Measurement (CASM) Program Origins

## **Problem**

- Inherent challenges in measuring Colorado's largest reservoir

## **Solution**

- ASO provides the most accurate measurement of snow water equivalent of all existing technologies

## **Stakeholder Interest**

- Water stakeholders showed substantial interest in developing a statewide, sustained approach to ASO

## **WSRF Grant Opportunity**

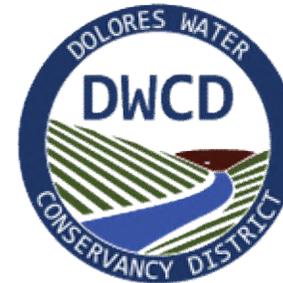
- CASM group awarded \$45,000 WSRF grant in March, 2021

[coloradosnow.org](http://coloradosnow.org)



# CASM Program

## Planning Team



## Stakeholder Workgroup

100+ member workgroup from diverse sectors and geographies

## Flight Coordination Committee

25+ member committee

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# California's ASO Program

- Airborne Remote Sensing of Snow (ARSS) Program
- Funded 31 flights in 2022 for \$9.6 million
- 2022 flights showed up to 50% less SWE than traditional estimates

“Having used this technology, it is hard to imagine a future without it.”

David Rizzardo, Chief of  
Snow Surveys and Water  
Supply Forecasting, CA DWR

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# CASM Vision Components

## **Vision 1 - Water Management and Decision-Support Applications**

Improved snowpack measurements and water supply forecasts that empower better water management decisions

## **Vision 2 - Hydroclimate Science**

Contributes to the advancement of watershed sciences

## **Vision 3 - Program Structure and Cooperative Management**

CASM is co-led by CWCB staff, with local stakeholders cooperating on flight decision-making and program subcommittees

## **Vision 4 - Funding**

Sustainable CASM program will require consistent state and/or federal funding.

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# CASM Buildout

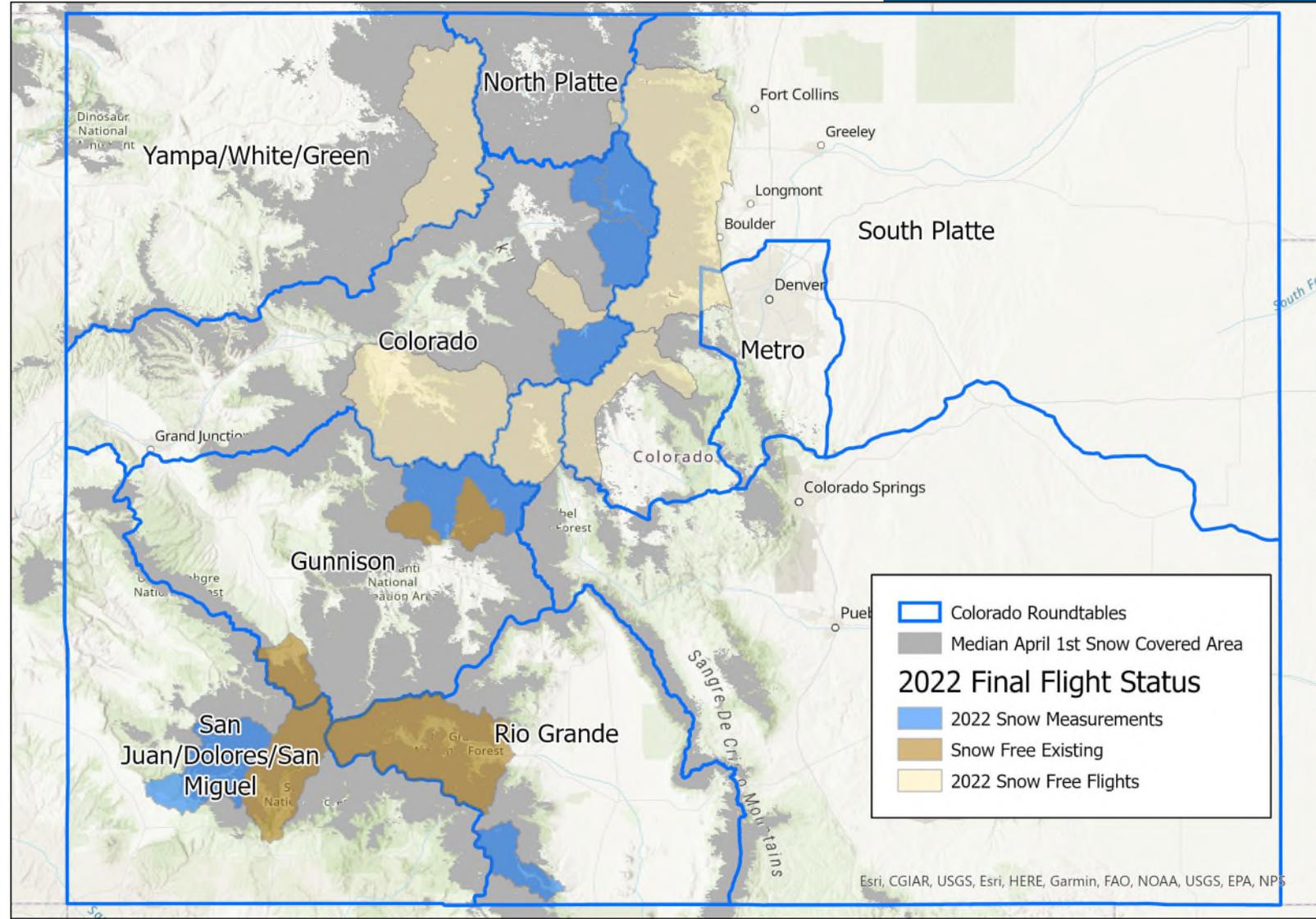
Phase	Timeline	Flights Per Year
Phase 1	2022	14
Case Study Building	2023	30 (2 flights in all prepped basins)
Widespread Adoption	2024-2026	64 (3 flights in all prepped basins)
Program Buildout	2026-2028	214 (6 Flights Across All Major Headwaters)

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# Water Plan Grant

- CASM was awarded \$1.9M WPG in March 2022
- 37 letters of support
- 14 snow-on flights
- WRF-Hydro runoff forecasting
- Snow-free flights
- CASM coordination and data workshops
- Streamflow forecasting integration project



# Next Steps for CASM

- Complete Water Plan Grant activities
- Explore CWCB integration
- Establish long-term, sustainable funding sources

## State Support

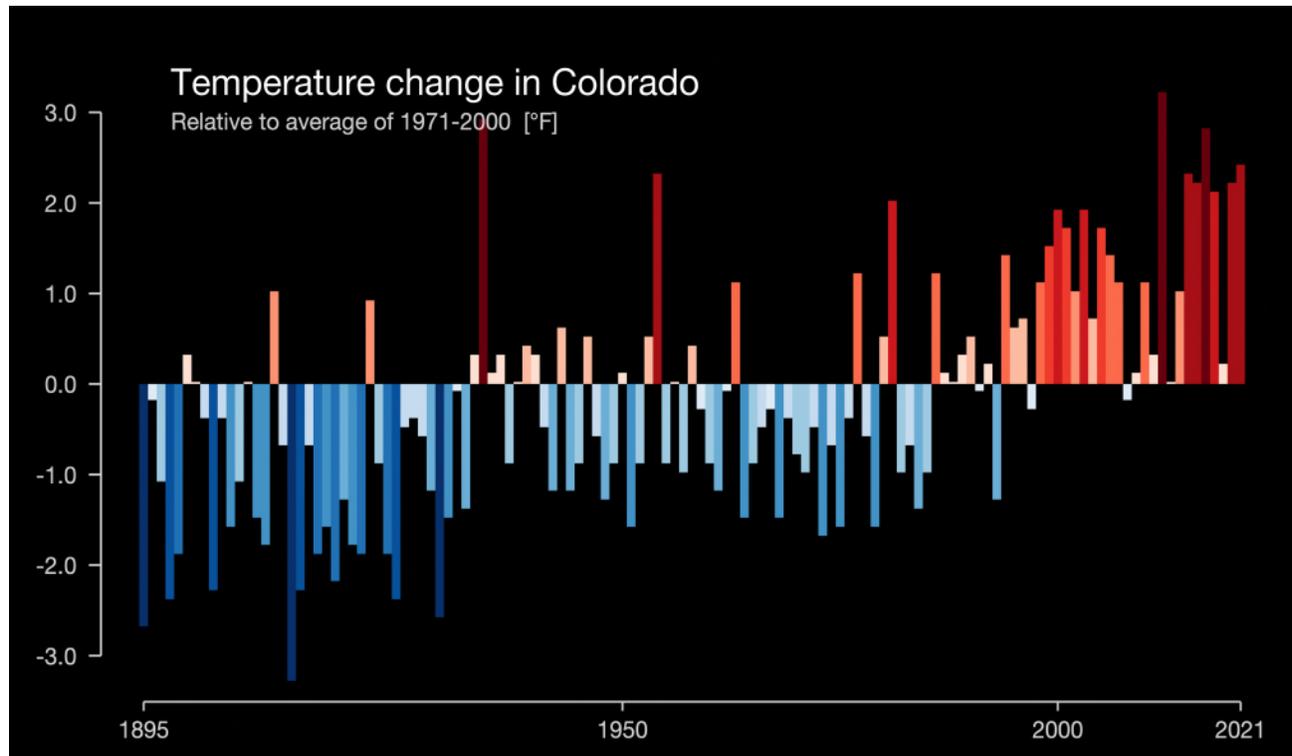
- CWCB support through Projects Bill, WPG, and staff support has greatly advanced the ASO/CASM program
- Continued State support & leadership through the CWCB will be crucial for sustainable program implementation

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# Powerful Climate Adaptation Tool

- Changing hydroclimate conditions require new management tools
- Cannot rely on historical record
- ASO provides tool to accurately measure what is happening now



source: showyourstripes.info

[coloradosnow.org](http://coloradosnow.org)



# Colorado Water Compacts

“Accurate snowpack/SWE monitoring and streamflow forecasts are critical to Colorado's ability to meet its compact obligations on the Rio Grande.

Our delivery obligation, and therefore the amount of water that can be used in Colorado, is based upon predictions of future streamflow amounts, so inaccurate predictions can cause a significant negative impact to Colorado water users.

ASO data can significantly enhance the accurate predictability of these future streamflows and provide Colorado with a better ability to meet these compact obligations while also fully utilizing the water that is allocated to Colorado users under the compact.”

- Craig Cotton, CO DNR, Division Engineer Division 3

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# Water Resources and Agriculture Review Committee

Ken Curtis, Dolores Water Conservancy District - August 24, 2022



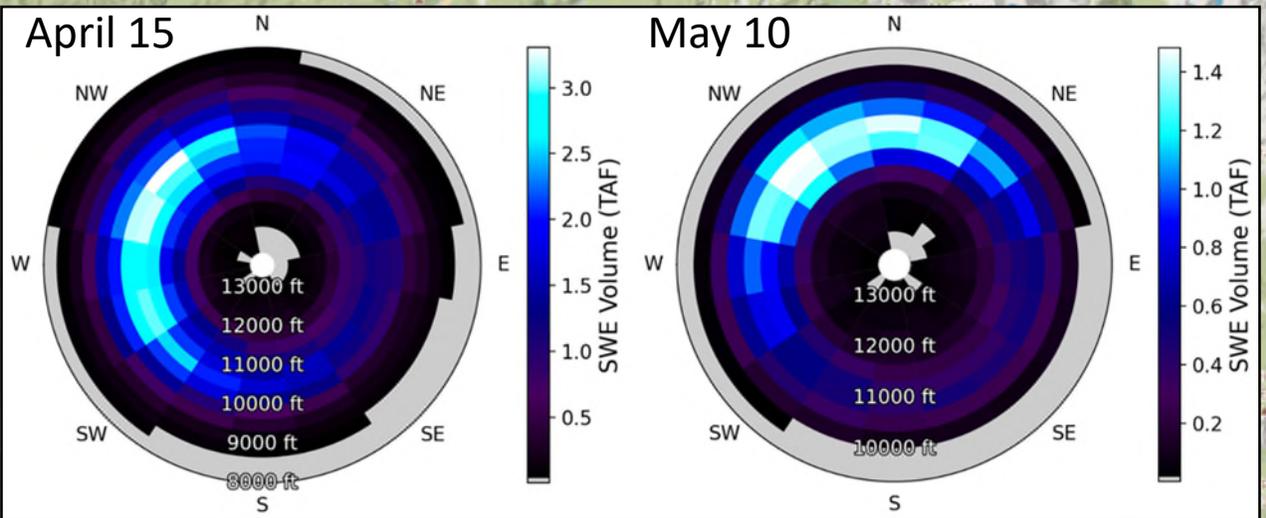
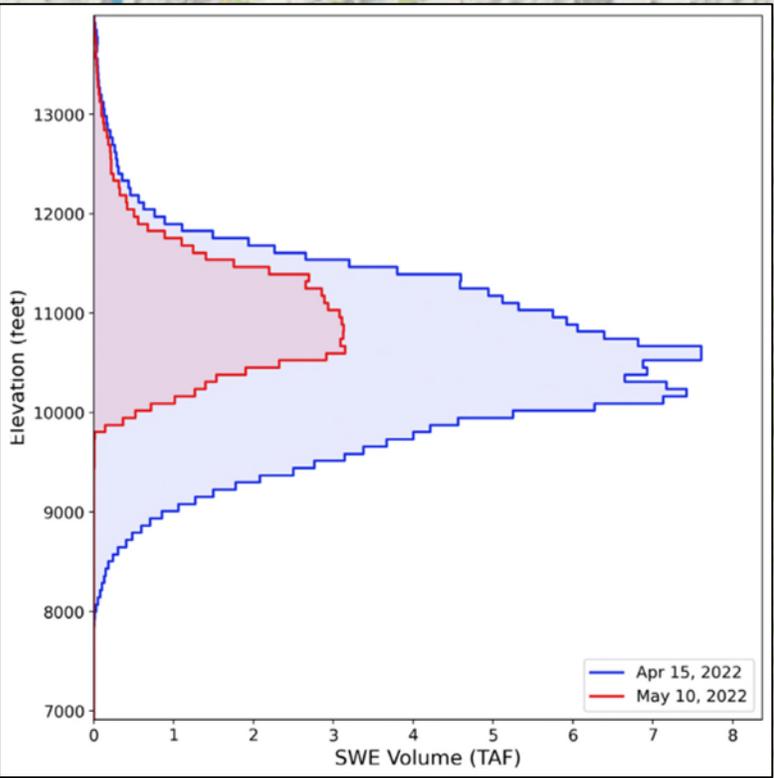
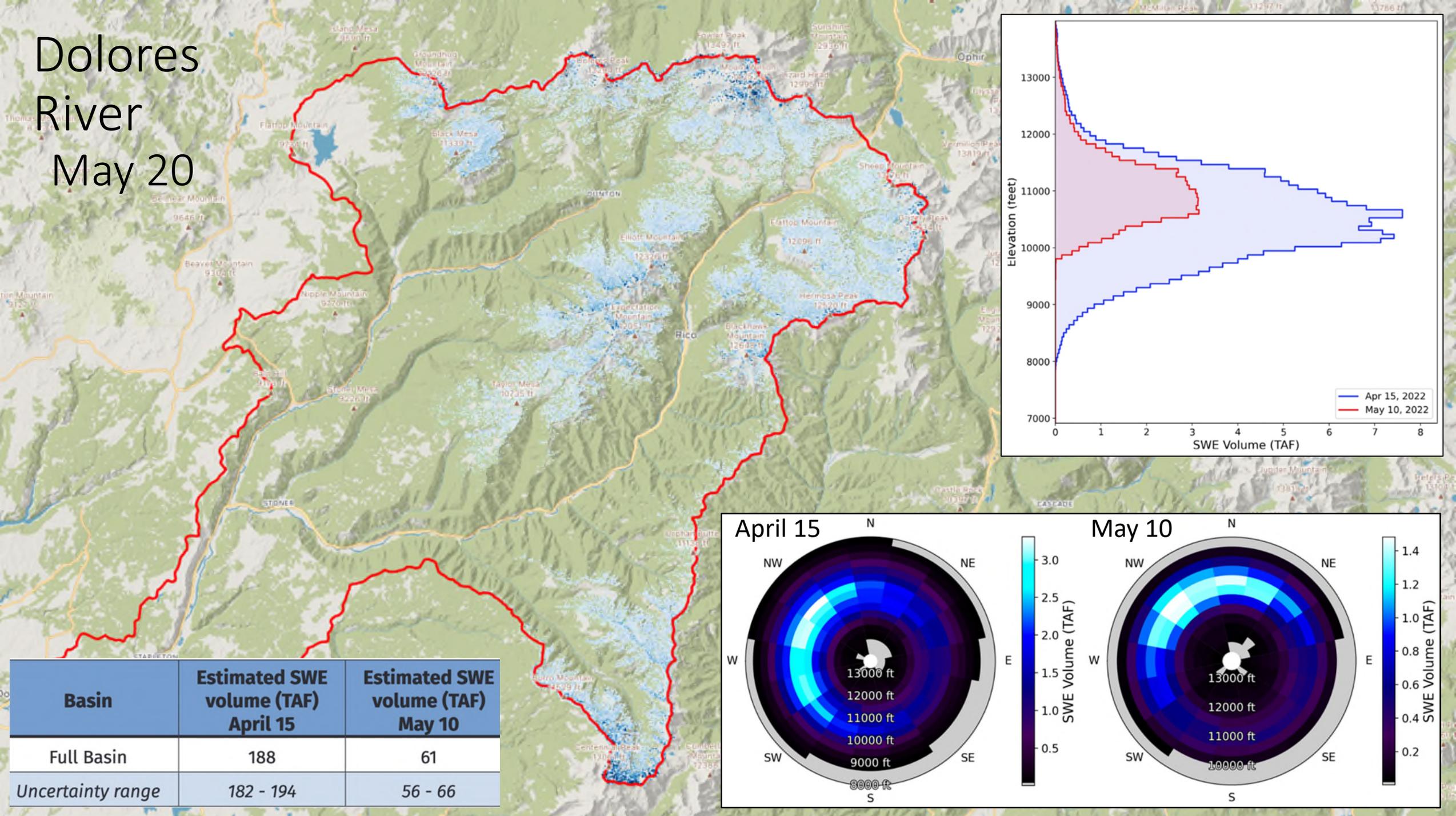


- Located in the Four Corners
- Dolores Project started 1977
- McPhee complete in 1986
- Senior Rights have river & supplemental
- All DP irrigators developed by 2000
- Fully pressurized, 22 inch supply supplied by storage, excess runoff
- Multiple dry years wipe out carryover
- 8 years of shortage:
  - **29%, 51%, 20%, 83%, 65%, 87%, 0%, 34%**
- Zero project supply (8-10% delivered, 1.7inches)

- We're operating on the hydrologic extremes
- We have to manage our water tighter to survive
- ***Best available real time data supports better runoff forecasts now and improves going forward***



# Dolores River May 20



Basin	Estimated SWE volume (TAF) April 15	Estimated SWE volume (TAF) May 10
Full Basin	188	61
Uncertainty range	182 - 194	56 - 66

“The information gained from ASO flights allows for a finer level of water management and provides more opportunity to benefit more users and get the maximum benefit out of every drop.”

*Nathan Elder*

*Raw Water Operations Manager  
Denver Water*

“What you’ve done is created new reservoir space and water supply without any impacts to the current physical or environmental paradigms.”

*Wes Monier*

*Chief Hydrologist  
Turlock Irrigation District*



“ASO data can provide Colorado with a better ability to meet these compact obligations while also fully utilizing the water that is allocated to Colorado users under the compact.”

*Craig Cotten*

*Colorado Division 3 Engineer*

“Having used this technology, it is hard to imagine a future without it.”

*Dave Rizzardo*

*Chief of Snow Surveys & Water  
Supply Forecasting  
CA DWR*

“ASO provides invaluable information about the rate of melt that provides a real opportunity to optimize reservoir operations for water supply, flood control, and instream requirements.”

*Steve Haugen*

*Watermaster  
Kings River Water Association*